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Green Corrosion Inhibitor for Protection of Mild Steel

Abstract- *In the present work, corrosion inhibition of Mild steel in 1M H_2SO_4 solution by Rosmarinus Officinalis Leaves extract was studied by weight loss and potentiostatic methods. Increasing acid concentration leads to an increase in the corrosion rate of the electrode. The variable conditions used in this investigation are (100 to 1000 ppm at 25°C. Rosmarinus Officinalis Leaves extract for Mild steel. It has been found that the concentrates as a compelling consumption inhibitor for gentle steel in acidic medium. The hindrance process is credited to the development of an adsorbed film of inhibitor on the metal surface, which secures the metal against corrosion. The inhibition efficiency was observed that increase with increasing inhibitor concentration up to maximum 92% for 1000 ppm at 25 °C. The results show that the corrosion rate without inhibitor is 5.6 mpy while with inhibitor be 0.43 mpy, that is mean the corrosion rate was improved more than 90%. The effects of immersion time (2 h) at 25°C on the inhibition of corrosion have also been improved corrosion resistance. The results obtained show that Rosmarinus Officinalis Leaves Extract could serve as an excellent friendly green corrosion inhibitor. FTIR results indicate that this herb containing different chemical bonds (C-C, CH_2, C-O-C, Cellulose) with steel surface producing barrier layer to protect the surface*

Keywords- *Green corrosion; Mild steel; Carbon steel;* Inhibitor

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1. Introduction

Steel is used to make a broad assortment of equipment and metallic structures because of its negligible exertion and extraordinary mechanical quality. A noteworthy piece of the steel that is created and presented to outdoors conditions, routinely in significantly atmospheres where utilization is essentially more outrageous than in clean common circumstances [1].

Many authors [1-3] studied the atmospheric, corrosion of, Mild steel as a broad point that has been considered by numerous makers. They have proposed unmistakable frameworks and methods, for concentrated the wonders included they have also detailed presentation brings about various locales all through the world. The climatic corrosion of mild, steel is a broad theme that has been considered by numerous scientists. They proposed distinctive strategies and components for concentrate the wonders involved. Atmospheric corrosion is a noteworthy issue for the use of designing materials in many sorts of administration. Therefore, there is a continuous push to comprehend this wonder and create measures that can be utilized to anticipate the seriousness of consumption procedures in administration conditions [1]. Among the few strategies for corrosion control and aversion, the utilization of consumption inhibitors is exceptionally prominent, and a standout amongst the most down to earth techniques for shielding metals or composites from consumption [2]. Corrosion inhibitors are substances which when included little focuses to destructive media diminish or keep the response of the metal with the media [3-4]. Natural inhibitors are for the most part applications like secure aluminum amalgams against consumption in forceful solution since they adsorb at first glance going about as a defensive layer on cathodic and anodic and area at the same time [5,6]. Furthermore, natural mixes containing polar gatherings, for example, N, S and O and in addition heterocyclic containing conjugated two fold bonds are accounted for a great consumption safe for Al and its amalgams [7].

There has been expanded enthusiasm for utilizing plant removes as corrosion inhibitors for metals in corrosive answer for manageable advancement. This is on account of plants fill in as fantastically rich wellsprings of normally blended synthetic exacerbates that are earth adequate, modest, promptly accessible and sustainable wellspring of materials [8-9].

May et al. [10] Studied a modern Halogen-Resistant Azole, (HRA) which has been improved for protected of copper and its alloys in aqueous solutions. This material provides superior copper protection compared to the industry standard [11]. Sami et al. Studied the inhibitive action of new natural and

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locally available materials, which are: Cyperus Papyrus (C.P) known locally as (Al-khreat) and Orange Peel (O.P) on the rate of corrosion of low carbon steel used in cooling towers at Al-Dura refinery [12]. Sami approved that the corrosion rate of copper alloy that used in heat exchangers decreases by using the Horsetail herb as green corrosion inhibitor [12]. This article reports the effects of Rosmarinus Officinalis extract on the corrosion of mild steel in 1M H_2SO_4 as acid solution, by applying weight loss and potentiostaic technique.

2. Experimental Procedure

Mild steel, of 2mm in thickness with the composition listed in table 1 supplied by lab. grade, were used for this research. Each sheet was cut into rectangular, specimens in dimension of 3*2*0.2 cm then grinding by using emery paper with a grade of, 220, 320, 500, 1000 and 2000 grade under running tap water on a mechanical grinder then rained with tap water followed by double distilled water, dried in the oven for 30min., degreased by immersing them in acetone then dried with tissue paper and kept in a dissector over a bed of silica gel. The specimens were then polished using (Dp-Heavy Diamond, Dp-Lubricant for metallographic grinding and polishing, Denmark). $H_2SO_4$was of analytical grade and 1M was preparation as the corrosion media solution for this study.

Table (1) Composition of mild steel

component	C	Mn	Cr	S	Fe
%	0.15	0.75	2.5	0.0008	balance

Preparation of Rosmarinus Officinalis extract

Rosmarinus Officinalis herb supplied from Iraqi marked. The extract of the herb was prepared by take 100 gram of the herb and crashed in high-speed electrical mill then sieved to get fine powder only. 10 gram of the fine powder Rosmarinus Officinalis herb were added to 0.1 litter of ethanol as a solvent in a reflux condenser for 1 hour then filtered for 30 minutes to obtain 50 milliliters of the extracted Rosmarinus Officinalis herb, different concentration of the extract 100, 200, 300,…1000ppm) was used as green inhibitor for mild steel specimens in 1 M H_2SO_4 solution.

The weight loss method determination was done as previously reported [11,12]. Previously weighed the specimens were immersed in100 mL open beakers containing 100 mL of 1M H_2SO_4 (stock solution) and then the specimens immersed in the same stock solution but with addition (100-1000 ppm) of extracted green inhibitor (Rosmarinus Officinalis) at room temperature. The weight losses of the specimens were recorded for 120min at 30 min steps. The experiments was repeated twice at the same conditions and the medium values were record. Corrosion rate (mpy), and inhibition efficiency (η%) were evaluated for 120 min immersion time using the equation (1):

$$\text{CR in mill per year (mpy)} = \frac{564W}{dAT} \quad \text{…. (1)}$$

Where:

W: The loss in weight in mg.

d: specimen density in g/Cm^3.

A: specimen surface area in in^2.

T: time of exposure in hr.

Electrochemical experiments were carried out in a computerized electrochemical, potentiostate with a three-electrode glass cell of capacity 100 mL. A saturated calomel electrode (SCE) is fixed with a Luggin capillary as reference electrode. A platinum foil of 1 cm * 1 cm is utilized as Auxiliary cathode. All potentials electrode measurements are applied relative to SCE. Before estimation, the working electrode is immersed in test solution for about 30 min until an steady state open-circuit potential (OCP) is recorded.

Corrosion rate calculated by using the following equation (2).

$$\text{Corrosion rate} = \frac{0.129 \times i_{corr} \times W_{eq}}{\rho \times A} \quad \text{… (2)}$$

Where:

$W_{eq.}$= Equivalent weight (g/equivalent)

ρ = Density of mild steel (g/cm^3)

A= Exposure area of specimen (cm^2)

i_{corr}= Corrosion current density (μA/cm^2)

3.Results and Discussion

I. Polarization measurements

Figures 1-11 and their results values are indicate in Table 2. All Figures show general corrosion behavior, of mild steel in 1 M H_2SO_4 solution without and with different, concentrations of the used inhibitor. Figures also show cathodic and anodic regions. These regions were effected due to the addition of different amounts of inhibitor. It could be watched that both cathodic and anodic reactions were influenced emphatically with the expansion of the herb, which recommended that the inhibitor applied an efficient inhibitory action both on an anodic oxidation of metal and on cathodic hydrogen reduction response. Electrochemical parameters, for example, E_{corr}, i_{corr}, and corrosion rate observed from the polarization estimations are recorded in Table 2. The inhibition efficiency (IEP%) was estimated by equation (3):

$$\eta = \frac{i_{corr} - i_{corr(inh)}}{i_{corr}} \times 100 \quad \text{….(3)}$$

Where i_{corr} and $i_{corr\ (inh)}$are the corrosion current, density values in the absence and presence of extracted Rosmarinus Officinalis herb, respectively.

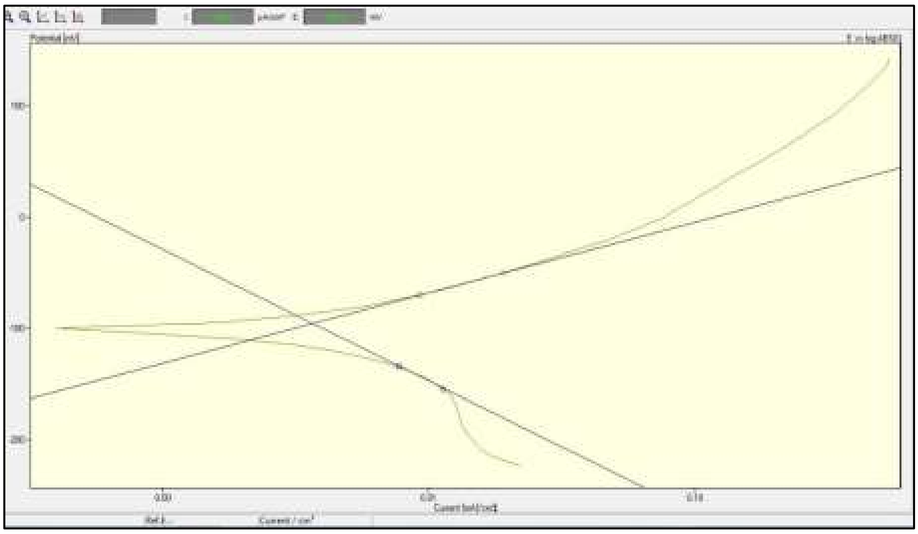

Figure1: Shows polarization curve of mild steel in uninhibited acid solution at 25^{o}C

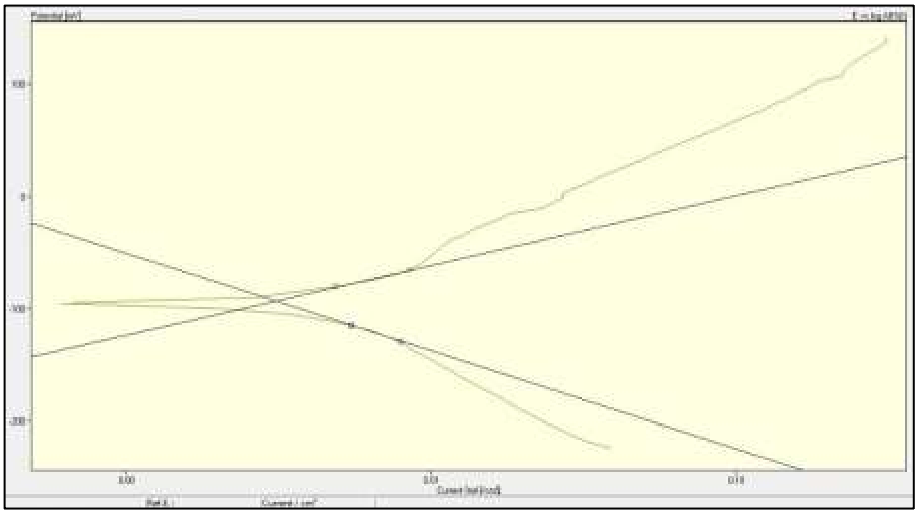

Figure 2: Polarization curve of mild steel in acid solution at 25^{o}C containing 100 ppm of green inhibitor

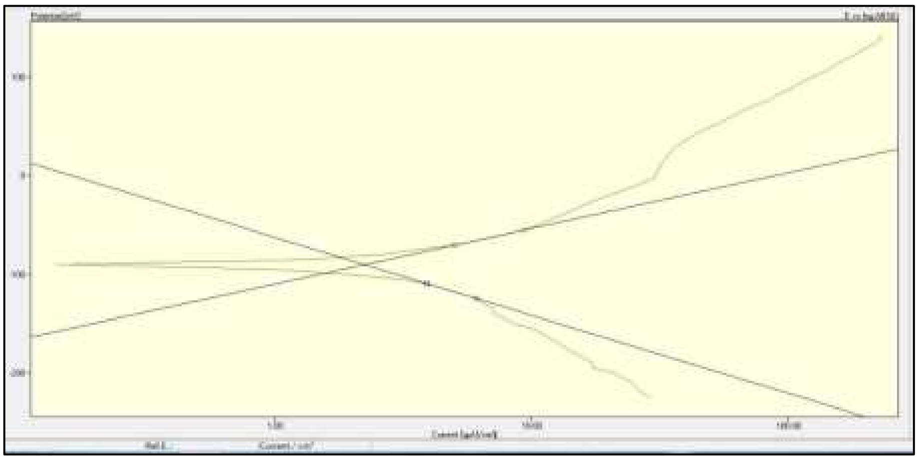

Figure 3: Polarization curve of mild steel in acid solution at 25^{o}C containing 200 ppm of green inhibitor

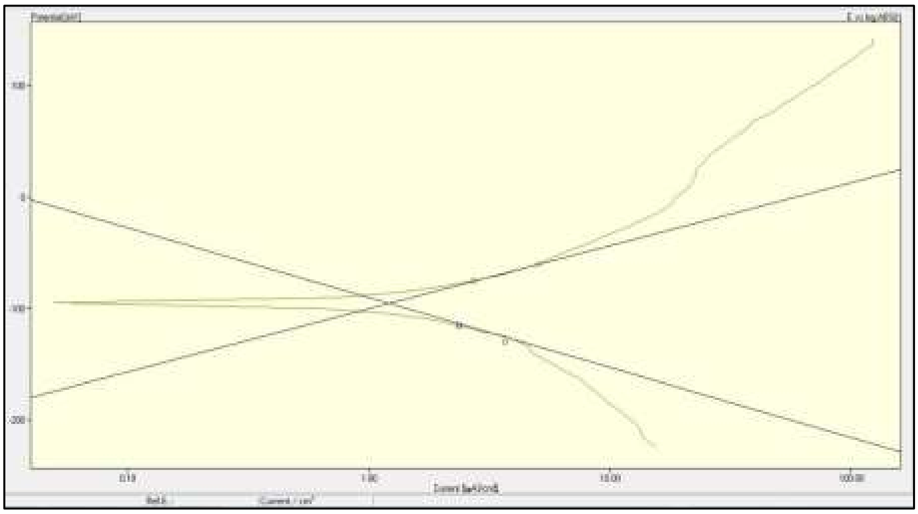

Figure 4: Polarization curve of mild steel in acid solution at 25°C containing 300 ppm of green inhibitor

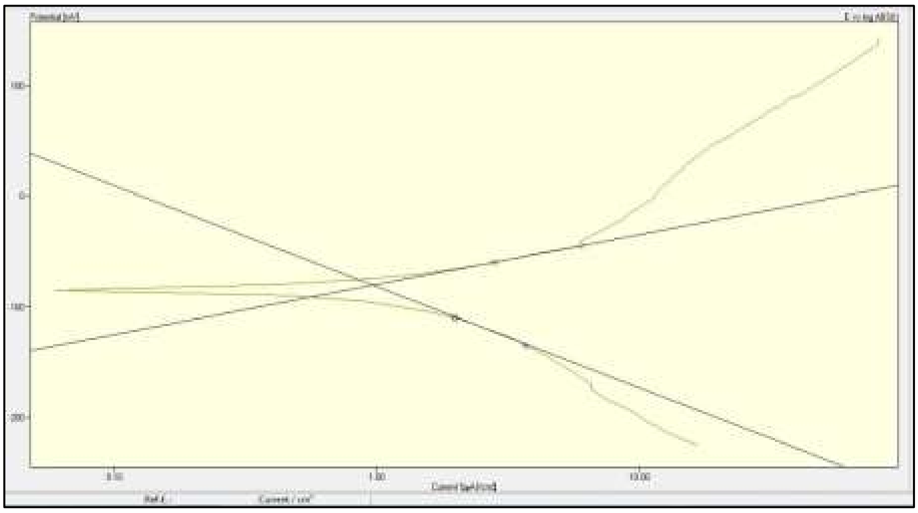

Figure 5: Polarization curve of mild steel in acid solution at 25°C containing 400 ppm of green inhibitor

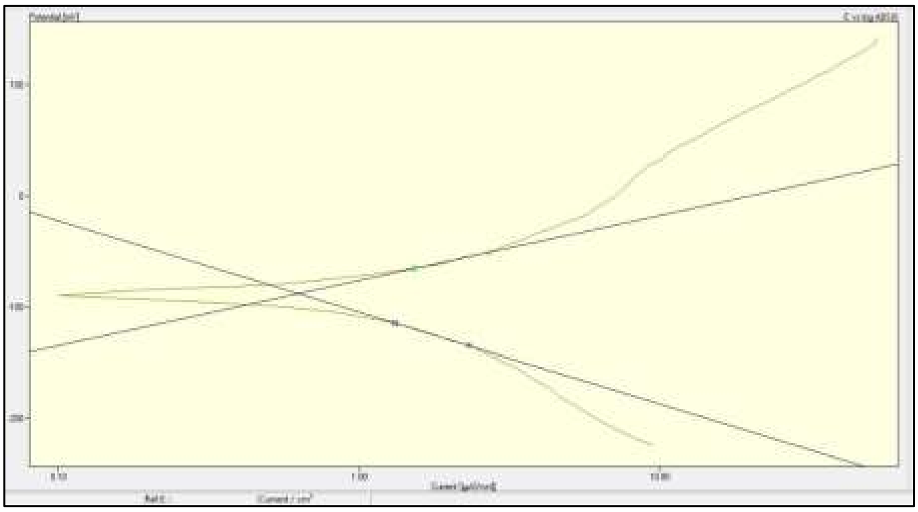

Figure 6: Polarization curve of mild steel in acid solution at 25°C containing 500 ppm of green inhibitor

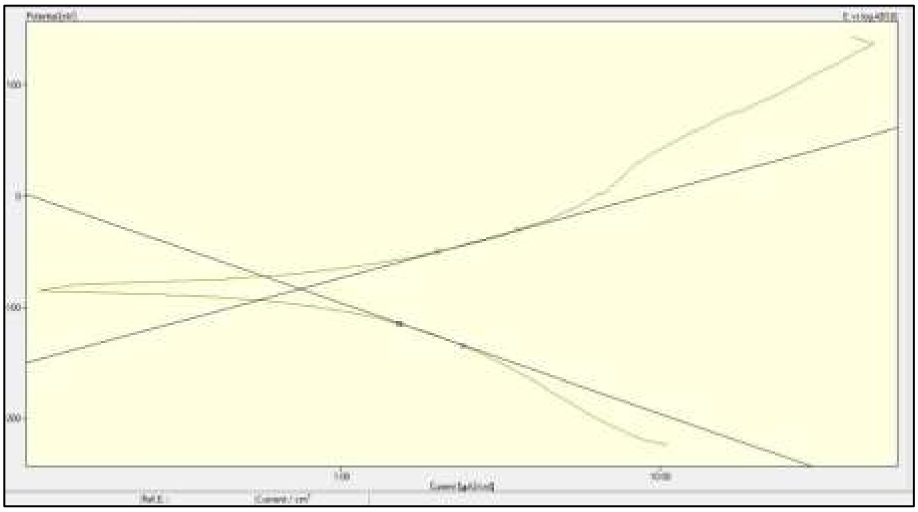

Figure 7: Polarization curve of mild steel in acid solution at 25°C containing 600 ppm of green inhibitor

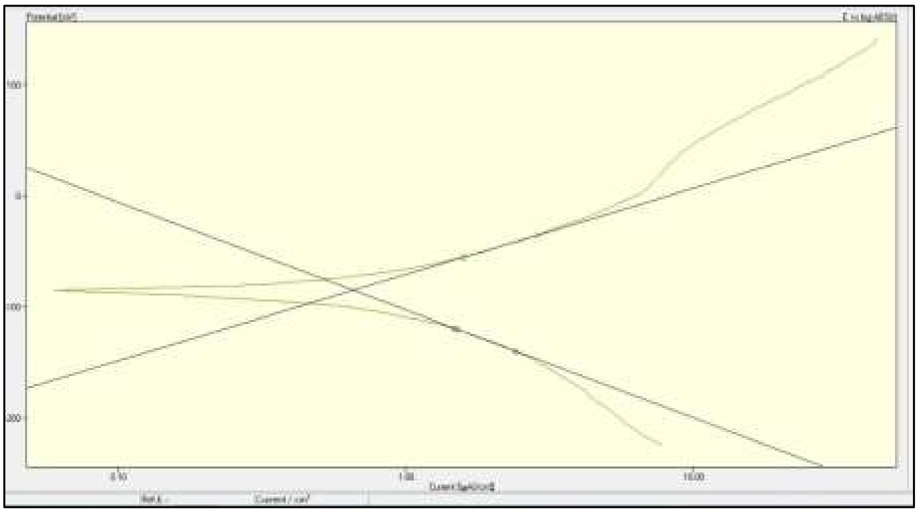

Figure 8: Polarization curve of mild steel in acid solution at 25°C containing 700 ppm of green inhibitor

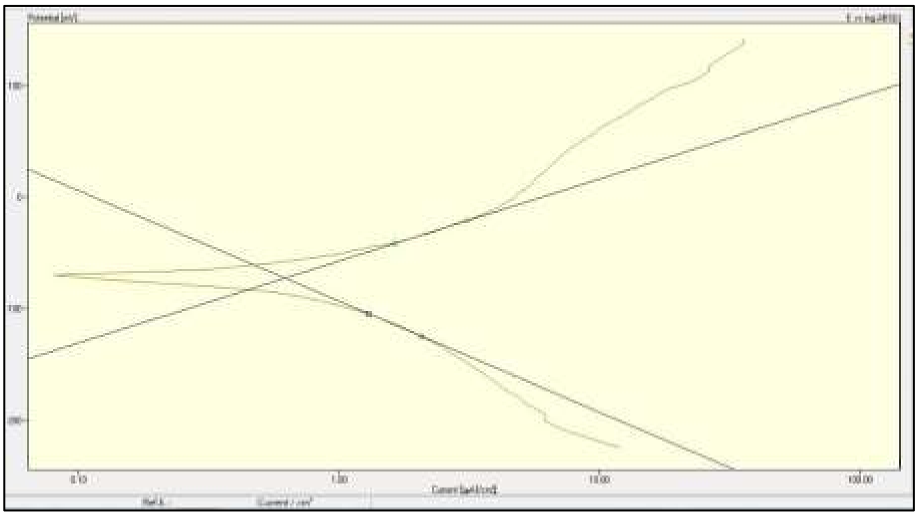

Figure 9: Polarization curve of mild steel in acid solution at 25°C containing 800 ppm of green inhibitor

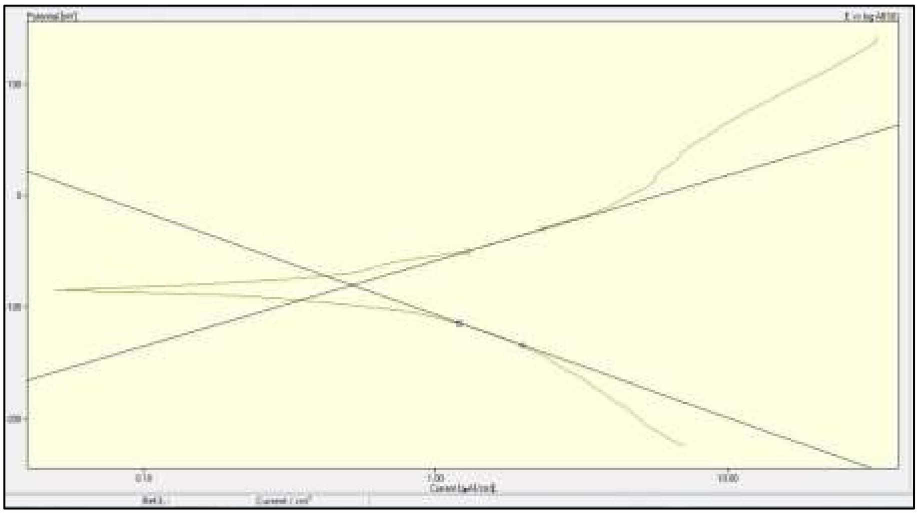

Figure 10: Polarization curve of mild steel in acid solution at 25°C containing 900 ppm of green inhibitor

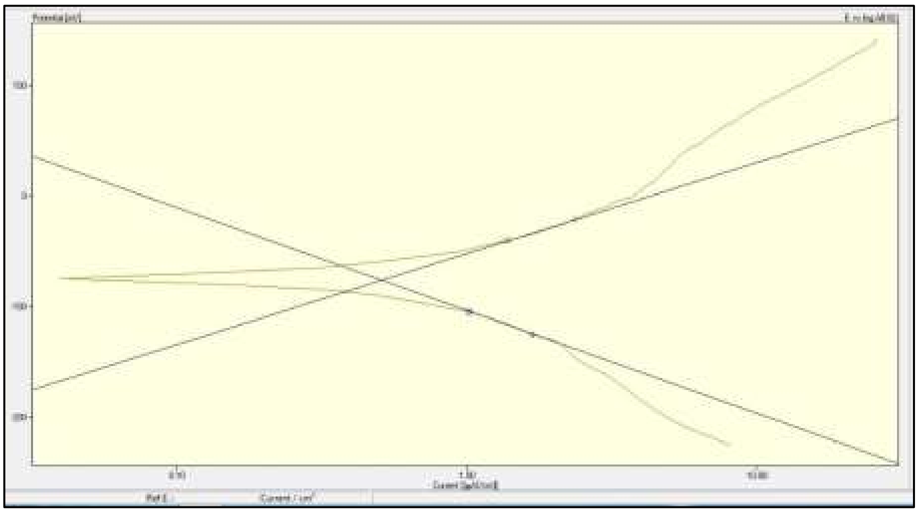

Figure 11: Polarization curve of mild steel in acid solution at 25°C containing 1000 ppm of green inhibitor

Table 2: Corrosion rate of mild steel in 1 M H_2SO_4 with and without green inhibitor in room temperature (Potentiostate technique)

Run No.	Conc. of inhibitor	Potential E_{cor} (mV)	Current Density i_{corr} ($\mu A/cm^2$)	Inhibitor efficiency%	CR mpy
1	Without inhibitors	-99.6	4.85	-	2.263
2	100 ppm	-97.1	3.71	٢٤	١.٧٣
3	200 ppm	-92.5	3.14	٣٥.٣	١.٤٦٥
4	300 ppm	-92.6	2.59	٤٦.٥٩	١.٢٠٨
5	400 ppm	-84.5	1.409	٧٠.٩	٠.٦٥٧
6	500 ppm	-89.5	1.127	٧٦.٧٦	٠.٥٢٥
7	600 ppm	-82.1	0.946	٨٠.٥	٠.٤٤١
8	700 ppm	-80.1	0.752	٨٥.٠٣	٠.٣٥١
9	800 ppm	-77.6	0.61	٨٧.٤٢	٠.٢٨٤
10	900 ppm	-77.5	0.44	٩٠.٩٢	٠.٢٠٥
11	1000 ppm	-70.1	0.385	٩٢.٠٦	٠.١٧٩

Polarization curves is normally utilized as a plot of the anode potential versus the logarithm of current density. Figure 1 shows the polarization curve for mild steel in 1 M H_2SO_4 without inhibitor. It is found that the current density about 4.85 $\mu A/cm^2$, and the current density decreases to 0.38 $\mu A/cm^2$ after adding 1000 ppm of Rosmarinus Officinalis due to the coating layer created on the surface of the mild steel specimen. Figures 1-11 show that the potential moved to more noble direction (from -0.6 without inhibitor to -70.1 after added 1000 ppm of Rosmarinus Officinalis)

II. Weight loss Technique

The dimensions of each specimen were exactly measured with a digital vernier to the 2nd decimals of millimeter and weighted by using digital balance to the 4th decimal of gram. For the weight loss measurements technique, the metal specimens were completely immersed in 100 Cm^3 of 1M H_2SO_4 containing (0, 100, 200, 300, 1000 ppm) of Rosmarinus Officinalis at room temperature herb solution at 25 ^oC in a beaker for 120 min and then recording the difference in weight. Corrosion rates in Rosmarinus Officinalis herb solution are recorded in Table 3. The rates are calculated by applying equation (1) for immersed specimens of area equal to ($14cm^2$ = 2.17 in^2), density (D) equal to 7.81 g. /cm3 and time of immersion (t) equal to (2 hr).

Figure 12 indicates that the corrosion rate decreases with an increase in inhibitor concentration due to the coating layer created on the metal surface.

III. FTIR Analysis

Figure 13 shows the analysis of Rosmarinus Officinalis herb by using FTIR technique, it is found that the active group that containing C-C, O–H, CH_2, C–O–C, group.

FTIR is a Modern technique to evaluate variations structural on the herb due to the chemical structure.

The FTIR spectrum of the samples was recorded in the transmittance mode in the range of 500-4000 cm^{-1}. FTIR spectra of Rosmarinus Officinalis herb having sharp in the region 966–1103 cm^{-1} because of the O–H bending due to adsorbed water, 1667-1720 cm^{-1} is because of CH_2 scissoring motion in cellulose), 1376-1515 cm^{-1} (C-H bending), 1687-1728 (O-H in plane bending) 2850- 2919 cm-1 (C–O–C pyranose ring stretching vibration), & (C–C ring stretching band), these data which revealed that Rosmarinus Officinalis herb are composed of crystalline cellulose. These FTIR spectral peaks can be applied to analysis of crystallinity of the samples consisting cellulose [13].

Table 3: Corrosion rate of mild steel in 1 M H_2SO_4 with and without green inhibitor in room temperature (weight loss technique)

Run	Conc. of inhibitor ppm	Time min.	ΔW mg	Corrosion rate MPY
1	0	120	0.144	2.268
2	100	120	0.13	2.048
3	200	120	0.11	1.733
4	300	120	0.091	1.433
5	400	120	0.088	1.386
6	500	120	0.082	1.292
7	600	120	0.076	1.197
8	700	120	0.071	1.118
9	800	120	0.057	0.898
10	900	120	0.04	0.63
11	1000	120	0.011	0.173

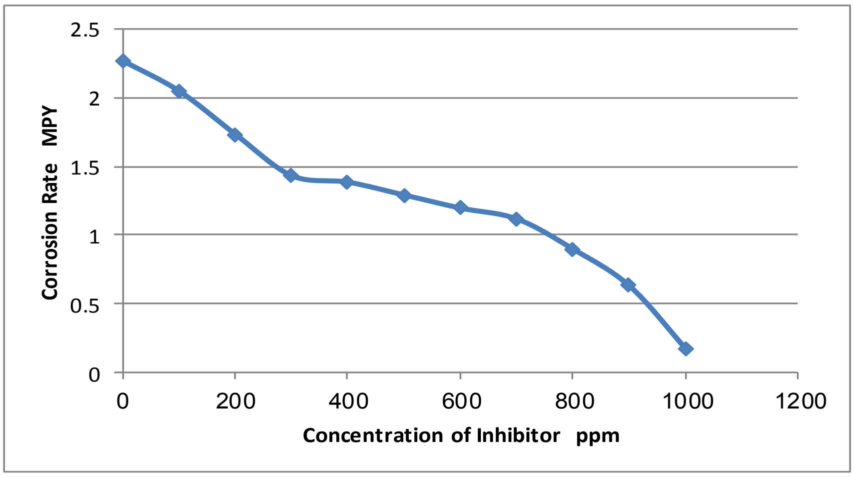

Figure 12: corrosion rate of of mild steel in 1 M H_2SO_4 with different concentration of green inhibitor at room temperature

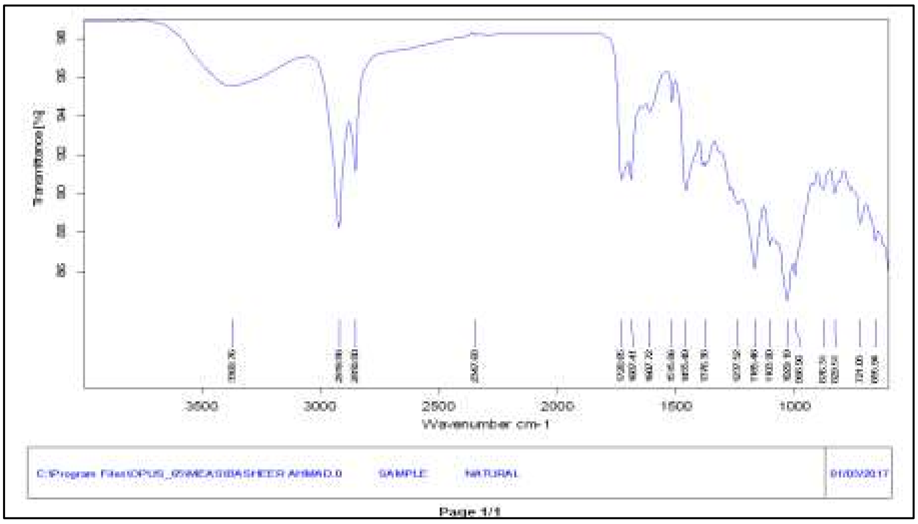

Figure 13: FTIR analysis of Rosmarinus Officinalis herb

4.Conclusions

Rosmarinus Officinalis herb concentrate was found to improve the corrosion rate of Mild steel in 1 M H_2SO_4 solution and inhibition efficiency increasing with increasing in herb extract concentration. At the most higher, concentrate herb extract of 1000 ppm, inhibition efficiency increasing especially and achieved 92%. Potentiostatic polarization bends demonstrated that the Rosmarinus Officinalis herb extract was a mixed-type inhibitor also the i_{corr} decrease with increasing in herb concentration.

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